Horizontal Variability in Surface Mixing in Response to Wind Forcing

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LONG-TERM GOALS

Our long term goal is to develop a tethered glider vehicle that will carry the microstructure profiler EPSONDE and to use this system to study the horizontal and vertical variability of mixing processes in the ocean mixed layer in response to atmospheric forcing.

OBJECTIVES

The technical objectives for the project have been to complete the mechanical design and testing of the EPSONDE-Glider including flight control design and testing of both hardware and software. Science objectives included performing quasi- horizontal turbulence profiles in the ocean mixed layer as part of an integrated field experiment. Objectives for the last year have been to analyze and publish data collected during the field program in 1996 and from recent testing on the DREA Barge in Bedford Basin. An effort has also been made to improve some characteristics of the instrument design.

APPROACH

This program involved the integration of an existing vertical profiler with a new mechanical superstructure to enable quasi-horizontal turbulence measurements. The approach minimized design and testing costs for the instrument. A field experiment complemented by vertical microstructure profiles, air-sea flux and wave spectra measurements was completed in the summer of 1996. Key individuals participation in the work were the PIs and Dr. Blair Greenan who supervised the instrument development.

WORK COMPLETED

The instrument design and testing was completed and a field experiment was carried out in June,1996 on the Scotian shelf on Emerald Bank at 43.483N, 62.75W. A total of 116 profiles were performed with the glider on the CSS Parizeau. As a complement to the glider measurements, the following measurements were performed: vertical microstructure profiles with EPSONDE, air-sea flux measurements with a bow anemometer system, boundary layer meteorological data collected with a minimet buoy, wave spectra from a wave rider buoy, ADCP and CTD profiles, wave measurements with a ship-mounted radar.

Additional development and testing has been carried out on the Defense Research Establishment Atlantic (DREA) Barge in Bedford Basin in Spring 1998 (Figure 1). A total of 62 glider profiles were interspersed with 60 vertical profiles of microstructure with EPSONDE. This series of profiling enabled us to implement and test some ideas about improving the design of the vehicle that became evident after using the instrument at sea.

Figure 1: Recovering EPSONDE-Glider after profiling from the DREA Barge.

A technical report which details the design and testing of the instrument has been completed, three papers on the experiment have been presented at meetings, and a paper has been accepted for publication in a journal. A paper on the 1996 field experiment is nearly ready for submission to complete this project.

RESULTS

EPSONDE-Glider has been successfully used at sea to gather microstructure profiles along a quasi-horizontal flight path close to the surface in the mixed layer during a field program in June of 1996. It provides a low-noise platform for near surface dissipation measurements with a noise level of order (10^{-9} W/kg). At the start of a profile the glider rests horizontally at the surface; when the tether is released the nose of the glider sinks below the surface and the pitch increases to 30 degrees but within 10 seconds levels out to a very stable pitch of 14 degrees and remains at this angle until the end of the run. The depth recorded by the pressure transducer increases linearly with time. The vehicle speed initially peaks around 0.6 m/s at the start of the run and then quickly settles to 0.55 m/s. Due to increased drag of the tether towards the end of the flight, the glider speed is reduced to 0.4 m/s. Using the speed and depth results, it is apparent that the actual glider path is a 4:1 ratio of horizontal to vertical distance traveled. The glider payload consisted mainly of the EPSONDE microstructure profiler which measures temperature and velocity microstructure using thermistors and velocity shear probes. Measurements of the rates of dissipation of turbulent kinetic energy and thermal variance are shown in Figure 2 for a series of five profiles carried out in June 1996. Estimates of diffusivity for these profiles are displayed in the bottom two panels of the Figure.

Recent improvements to the main wing design of the glider were tested on the DREA Barge in Bedford Basin (July 1998). The results from these tests showed an improved glide ratio in the range of 5:1 to 6:1, suggesting that careful attention to minimizing drag in this instrument design enables us to provide improved sampling of the mixed layer. The overall drag of the vehicle depends significantly on the tether cable design and future plans should consider this aspect very carefully.

IMPACT/APPLICATIONS

The successful tests and use of EPSONDE-Glider have provided the technical information necessary to this new approach to microstructure profiling. The results have demonstrated that the glider is a feasible platform with a low noise level on the order of 1E-9 W/kg. Possible applications of this design include near-surface microstructure profiling and profiling in situations in which more vertical resolution is needed than can be provided by traditional vertical profilers. One such application could be profiling in "thin layers" of phytoplankton which exist in coastal waters.

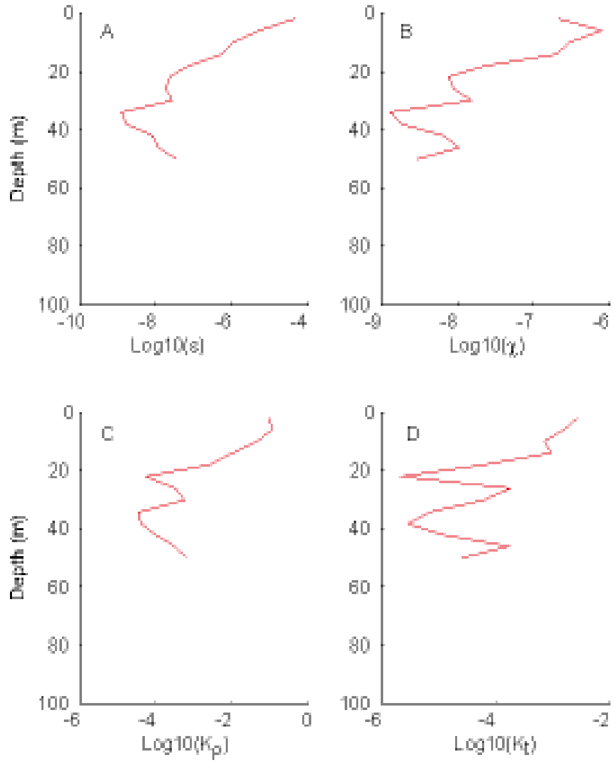

Figure 2: Mean profiles for EPSONDE-Glider station 009 (Profiles 006-010) at 1800Z, June 25, 1996. Data are presented in 4-m bin averages. Panels A and B represent the rate of dissipation of turbulent kinetic energy ( ) and thermal variance ( ). Panels C and D represent estimates of diffusivity. The glider is capable of sampling microstructure and turbulent shear within a few metres of the ocean surface.

TRANSITIONS

RELATED PROJECTS

PUBLICATIONS

Greenan, B.J.W., **N.S. Oakey**, 1998. A Tethered Free-Fall Glider to Measure Ocean Turbulence, Journal of Atmospheric and Oceanic Technology (accepted).

Greenan, B.J.W, **N.S. Oakey**, F.W. Dobson, 1998. Near-Surface measurements of ocean turbulence with a tethered free-fall glider. Proceedings of 32nd Canadian Meteorological and Oceanographic Society Congress, Halifax, 1-4 June.

Greenan, B.J.W., **N.S. Oakey**, S.W. Young, L.D. Clark, J.-G. Dessureault, 1997. A Tethered Free-Fall Glider to Measure Ocean Turbulence. Canadian Technical Report of Hydrography and Ocean Sciences 186: vii + 193pp.

Greenan, B.J.W., F.W. Dobson, **N.S. Oakey**, S.D. Smith,1997. Horizontal Variability in Ocean Surface Mixing in Response to Wind Forcing, Poster paper presented at the “12th Symposium on Boundary Layers and Turbulence”, Vancouver, July 28 - August 1.

Greenan, B.J.W., **N.S. Oakey**, 1997. Measuring Turbulence With a Tethered Free-Fall Glider, Proceedings of the Oceans ‘97 MTS/IEEE Conference, Halifax, 6-9 October.